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Non-pesticidal management of *Leucinodes orbonalis* (Guenee) in brinjal

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Abstract
The present study was conducted during 2018-19 at Chili and vegetable Research Unit, Central Research Station, Dr. PDKV Akola. The experiment laid out in Randomized Block Design with nine treatments *viz.* Removal of Infested shoots, Light Traps, NSE (5%) and their combinations in comparison with a Pesticide treatment and a Control (Untreated) replicated thrice. The observations were recorded on percent shoot infestation and fruit infestation (weight and number basis). The result indicated, T_7 (Removal of infested shoots + Light Trap + NSE (5%)) was the best alternative to T_8 (Pesticides spray) for maximum marketable fruits with minimum shoot and fruit infestation. Both the treatments T_7 and T_2 were effective for the non pesticidal management of brinjal shoot and fruit borer.

Keywords: *Leucinodes orbonalis*, removal of infested shoots, light traps, neem seed extract, randomised block design, non-pesticidal management

1. Introduction
Brinjal shoot and fruit borer (BSFB) is the major threat to brinjal cultivation which commences from 45 to 55 days after transplanting of brinjal seedlings in summer and *kharif* season, respectively and continues up to harvest. The infestation in summer and *kharif* season ranged from 7.56 to 23.55 and 17.24 to 30.87 on shoots and 10.06 to 25.27 and 23.34 to 47.75 percent fruits on number and weight basis, respectively (Dhamdhere *et al.* 1995) [1]. The larvae of this pest have been estimated to cause 12.6 percent damage to shoots and 20-60 percent damage to fruits. The activity of the pest is seen throughout the year and cause heavy losses during rainy and summer seasons which are estimated to 95 percent. (Chakraborti and Sarkar, 2011) [2] estimated losses due to this pest from 70-92 percent and (Yadav *et al*. 2015) [3] observed borer infestation up to 78.66 percent on top shoots and on flowers and fruits up to 66.66 percent.
BSFB is difficult to control by any insecticidal spray because it is an internal feeder and has developed resistance to conventional insecticides. Insecticide resistance is emerging as one of key constraints to successful crop protection and public health problem worldwide (Dover and Croft, 1984) [4].
Management of this pest at farmer level is through calendar spraying of conventional insecticides irrespective of pest incidence. The increased dependence on insecticides, calendar based sprays by the farmer and short residual action of certain group of insecticides have lead to higher costs of production and also inadequate control of pest. The extensive and indiscriminate use of pesticides for fruit and shoot borer management has led to several problems like resurgence of secondary pests, health hazards and insecticide residues making it unfit for consumption. Hence, present investigation was undertaken to evaluate the performance of certain physical, mechanical and botanical methods for managing this pest.

2. Materials and Methods
The experimental field was laid out in Randomized Block Design with nine treatments replicated thrice. All the agronomical practices were carried out as per the recommendations. The variety of brinjal seed used was Aruna. Light traps were personally prepared and customized for the experiment, Neem Seed Extract (5%) was prepared in the field by soaking the crushed neem seeds overnight. Removal of infested shoots was carried out manually by labour. Pesticide used in T_8 is cypermethrin 25 EC. The treatments were initiated immediately as soon as infestation was observed. Nine sprays were applied at 15 days interval. Observations recorded are as follows:

2.1 At vegetative stage

Percent Shoot infestation

From each plot, five plants were selected randomly and labeled for recording observations. As soon as the infestation of the pest on shoot was initiated, the observations on total number of shoots and number of infested shoots of five observational plants from each treatment replication wise were recorded at 3, 7, and 14 days after imposing treatments.

$$\text{Percent shoot infestation } \frac{\text{Number of infested shoots}}{\text{Number of total shoots}} \text{ X } 100$$

2.2 At fruiting stage

Percent infested fruits on number basis

The numbers of infested and healthy fruits were recorded at the time of each picking of five observational plants.

$$\text{Fruit borer infestation (Number basis)} = \frac{\text{Number of infested fruits}}{\text{Total no. of fruits plucked}} \text{ X } 100$$

Percent infested fruits on weight basis

At each picking the weight of healthy and infested fruits were recorded on weight basis of five observational plants from each treatment replication wise. First border plants brinjal fruits were removed and kept separate. The damaged and healthy fruits were counted and also the weight was recorded from net plot harvested fruits.

$$\text{Percent fruit damage (Weight basis)} = \frac{\text{Weight of damaged fruits}}{\text{Weight of total fruits plucked}} \text{ X } 100$$

Table 1: Treatment details are as follows

Treatments	Treatment details
T_1	Removal of infested shoots
T_2	Light trap
T_3	Neem Seed Extract (5%)
T_4	Removal of infested shoots + Light trap
T_5	Removal of infested shoots + NSE (5%)
T_6	Light trap + NSE (5%)
T_7	Removal of infested shoots + Light Trap + NSE (5%)
T_8	Pesticides spray (Recommended)
T_9	Control (Untreated)

3. Results and Discussion

The cumulative effect of treatments on shoots infestation 3, 7 and 14 days after spraying was presented in Table no. 2. While the cumulative effect of treatments on mean percent fruit infestation on weight and number basis was presented in Table no. 3.

3.1 Cumulative effect of treatments on shoot infestation after 3 days of spraying

Significantly minimum damage after 3 days on shoot by *L. orbonalis* was recorded in treatment Insecticide spray (T_8) recording 10.25 percent infestation. The next treatment T_7 (Removal of infested shoots + Light Trap + NSE 5%) recorded 11.83 percent infestation. Other treatments which performed in ascending order of damage to shoot by *L. orbonalis* were T_6 (Light trap + NSE 5%) 16.89 percent, T_4 (Removal of infested shoots + Light trap) 17.56 percent, T_5 (Removal of infested shoots + NSE 5%) 18.33 percent, T_2 (Light trap) 19.21 percent, T_3 (Neem Seed Extract 5%) 20.48 percent, T_1 (Removal of infested shoots) 32.84 per cent damage to shoots. Maximum damage 47.90 per cent was observed in T_9 (Control, Untreated).

Maximum percent reduction in shoot damage over control was observed in recommended Insecticide (T_8) 78.60 percent followed by T_7 (Removal of infested shoots + Light Trap + NSE 5%) 75.30 percent, T_6 (Light trap + NSE 5%) 64.73 percent, T_4 (Removal of infested shoots + Light trap) 63.34 percent, T_5 (Removal of infested shoots + NSE 5%) 61.73 percent, T_2 (Light trap) 59.89 percent, T_3 (Neem Seed Extract 5%) 57.24 percent and T_1 (Removal of infested shoots) 31.44 percent. (Fig no. 1)

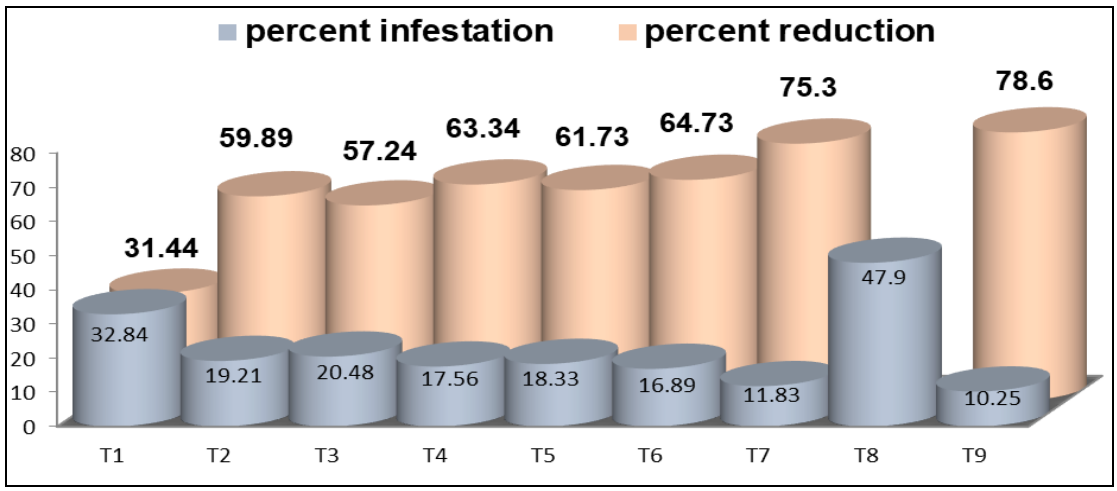

Fig 1: Cumulative effect after 3 days of spraying on percent infestation and reduction of *L. orbonalis* over control

3.2 Cumulative effect of treatments on shoot infestation after 7 days of spraying

Significantly minimum damage after 7 days on shoot by *L. orbonalis* was recorded in treatment Insecticidal spray (T_8) recording 11.09 percent infestation. The next treatment T_7 (Removal of infested shoots + Light Trap + NSE 5%) recorded 11.39 percent infestation. Other treatments which performed in ascending order of damage to shoots by *L. orbonalis* were T_6 (Light traps + NSE 5%) 15.23 percent, T_4 (Removal of infested shoots + Light trap) 16.41 percent, T_5 (Removal of infested shoots + NSE 5%) 17.58 percent, T_2 (Light trap) 18.97 percent, T_3 (Neem Seed Extract 5%) 19.36 percent, T_1 (Removal of infested shoots) 32.78 percent damage to shoots. Maximum damage 47.78 percent was observed in T_9 (Control (Untreated)).

Maximum percent reduction in shoot damage over control was observed in recommended Insecticide (T_8) 76.78 percent followed by T_7 (Removal of infested shoots + Light Trap + NSE 5%) 76.16 percent, T_6 (Light traps + NSE 5%) 68.12 percent, T_4 (Removal of infested shoots + Light trap) 65.65 percent, T_5 (Removal of infested shoots + NSE 5%) 63.20 percent, T_2 (Light trap) 60.29 percent, T_3 (Neem Seed Extract 5%) 59.48 percent and T_1 (Removal of infested shoots) 31.39 percent. (Fig no. 2)

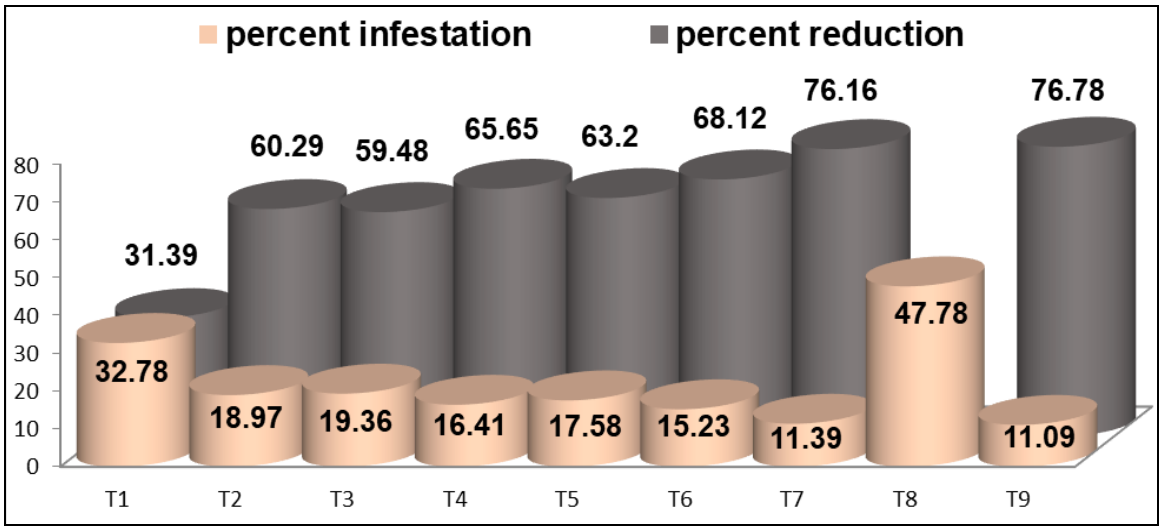

Fig 2: Cumulative effect after 7 days of spraying on percent infestation and reduction of *L. orbonalis* over control

3.3 Cumulative effect of treatments on shoot infestation after 14 days of spraying

Significantly minimum damage after 14 days on shoot by *L. orbonalis* was recorded in treatment Insecticidal spray (T_8) recording 12.87 percent infestation. The next treatment T_7 (Removal of infested shoots + Light Trap + NSE 5%) recorded 13.06 percent infestation. Other treatments which performed in ascending order of damage to shoot by *L. orbonalis* were T_6 (Light traps + NSE 5%) 18.17 percent, T_4 (Removal of infested shoots + Light trap) 19.42 percent, T_2 (Light trap) 19.82 percent, T_5 (Removal of infested shoots + NSE 5%) 20.12 percent, T_3 (Neem Seed Extract 5%) 21.38 percent, T_1 (Removal of infested shoots) 34.44 percent damage to shoots. Maximum damage 47.43 percent was observed in T_9 (Control (Untreated)).

Maximum percent reduction in shoot damage over control was observed in recommended Insecticide (T_8) 72.86 percent followed by T_7 (Removal of infested shoots + Light Trap + NSE 5%) 72.46 percent, T_6 (Light trap + NSE 5%) 61.69 percent, T_4 (Removal of infested shoots + Light trap) 59.05 percent, T_2 (Light trap) 58.21 percent, T_5 (Removal of infested shoots + NSE 5%) 57.57 percent, T_3 (Neem Seed Extract 5%) 54.92 percent and T_1 (Removal of infested shoots) 27.38 percent. (Fig no. 3)

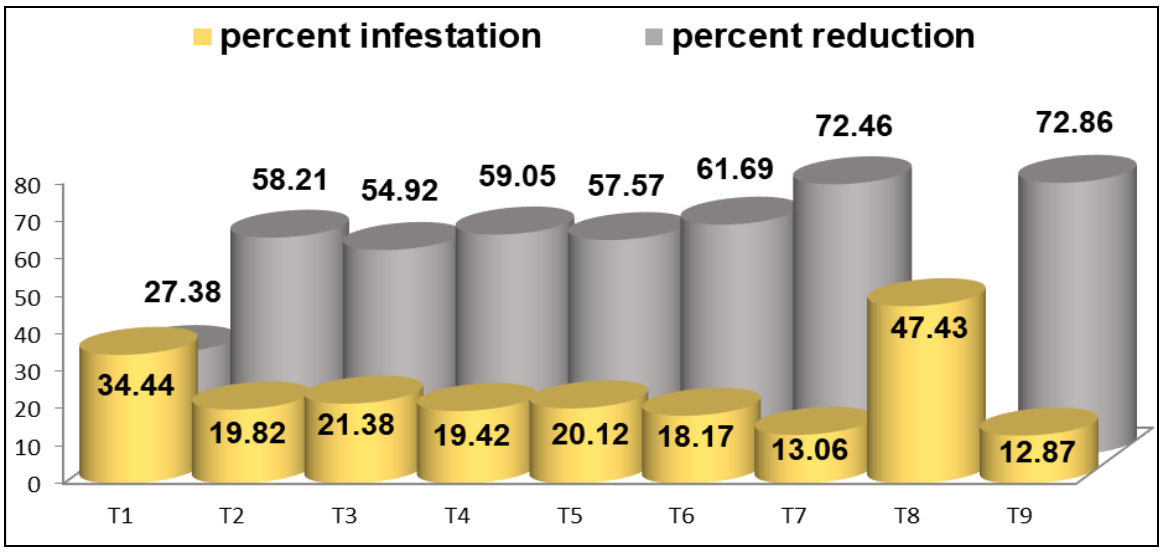

Fig 3: Cumulative effect after 14 days of spraying on percent infestation and reduction of *L. orbonalis* over control

3.4 Cumulative mean percent fruit infestation on weight basis

Significantly minimum damage on weight basis by *L. orbonalis* was recorded in treatment insecticide spray (T_8) recording 10.72 percent infestation. The next treatment T_7 (Removal of infested shoots + Light Trap + NSE 5%) recorded 11.48 percent infestation. Other treatments which performed in ascending order were T_6 (Light trap + NSE 5%) 15.78 percent, T_4 (Removal of infested shoots + Light trap) 16.05 percent, T_5 (Removal of infested shoots + NSE 5%) 16.87 percent, T_2 (Light trap) 17.22 percent, T_3 (Neem Seed Extract 5%) 18.78 percent, T_1 (Removal of infested shoots) 27.89 percent damage to shoots. Maximum damage 35.57 percent was observed in T_9 (Control (Untreated)).

Maximum percent reduction in shoot damage over control was observed in recommended pesticide (T_8) 66.14 percent followed by T_7 (Removal of infested shoots + Light Trap + NSE 5%) 67.72 percent, T_6 (Light trap + NSE 5%) 55.63 percent, T_4 (Removal of infested shoots + Light trap) 54.87 percent, T_5 (Removal of infested shoots + NSE 5%) 52.57 percent, T_2 (Light trap) 51.58 percent, T_3 (Neem Seed Extract 5%) 47.20 percent and T_1 (Removal of infested shoots) 21.59 percent. (Fig no. 4)

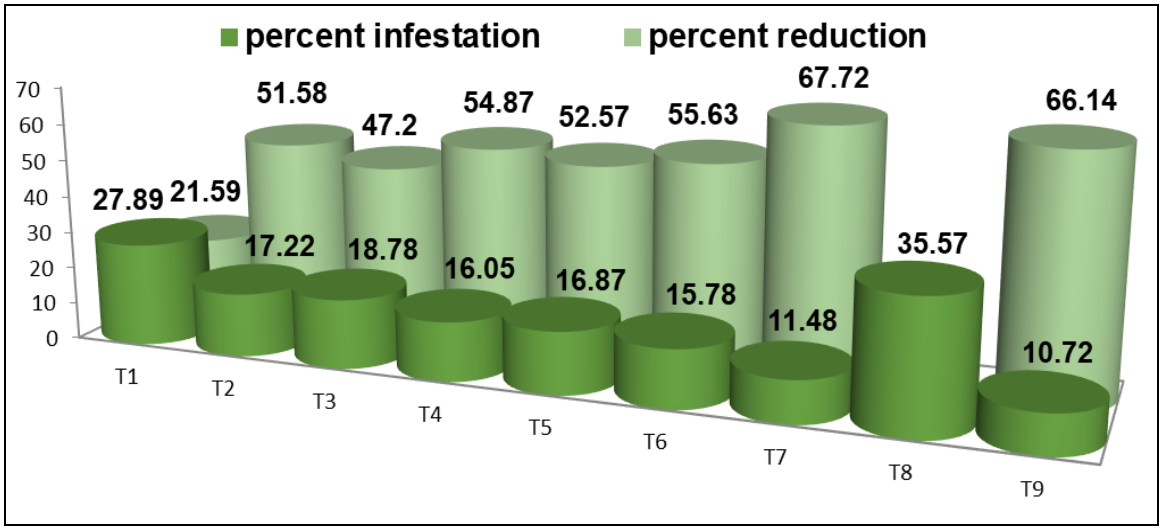

Fig 4: Cumulative percent infestation and reduction of *l. orbonalis* over control on fruits (weight basis)

3.5 Cumulative mean percent fruit infestation on number basis

Significantly minimum damage on weight basis by *L. orbonalis* was recorded in treatment insecticide spray (T_8) recording 10.15 percent infestation. The next treatment T_7 (Removal of infested shoots + Light Trap + NSE 5%) recorded 11.03 percent infestation. Rest of the treatments performed in ascending order were T_6 (Light trap + NSE 5%) 14.68 per cent, T_4 (Removal of infested shoots + Light trap) 15.37 percent, T_5 (Removal of infested shoots + NSE 5%) 16.07 percent, T_2 (Light trap) 16.56 percent, T_3 (Neem Seed Extract 5%) 17.87 percent, T_1 (Removal of infested shoots) 26.47 percent damage to shoots. Maximum damage 33.85 percent was observed in T_9 (Control (Untreated)).

Maximum percent reduction in shoot damage over control was observed in recommended insecticide (T_8) 70.01 percent followed by T_7 (Removal of infested shoots + Light Trap + NSE 5%) 67.41 percent, T_6 (Light trap + NSE 5%) 56.63, T_4 (Removal of infested shoots + Light trap) 54.59, T_5 (Removal of infested shoots + NSE 5%) 52.52 percent, T_2 (Light trap) 51.07 percent, T_3 (Neem Seed Extract 5%) 47.20 percent, T_1 (Removal of infested shoots) 21.80 percent. (Fig no. 5)

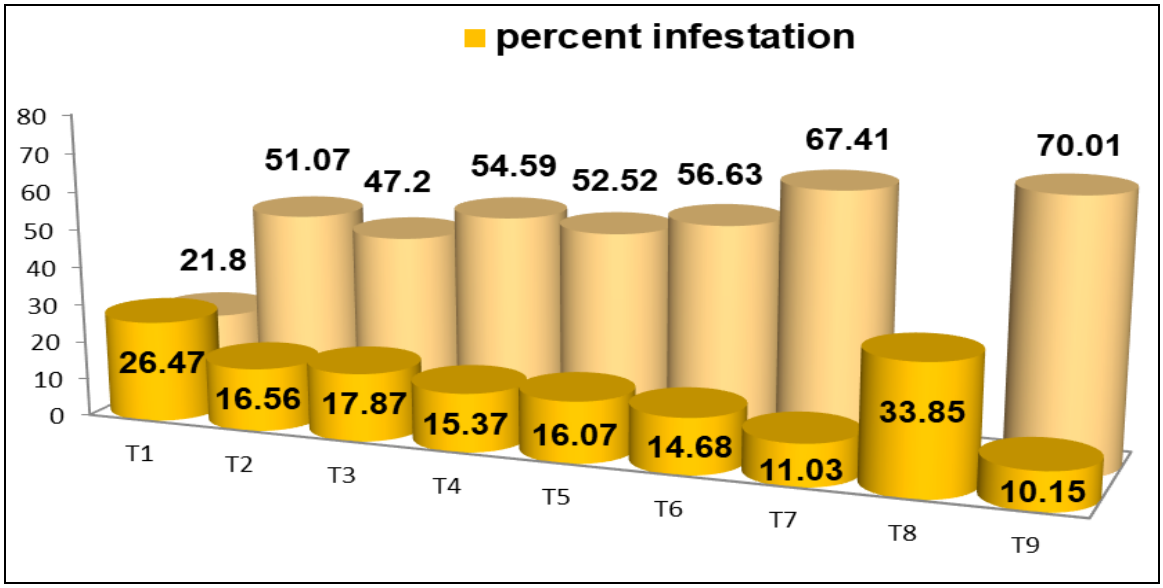

Fig 5: Cumulative percent infestation and reduction of *L. orbonalis* over control on fruits (number basis)

Table 2: Cumulative effect of treatments on shoots infestation 3, 7 and 14 days after spraying

Treatment		3 DAS		7 DAS		14 DAS	
		Mean	Percent Reduction Over control	Mean	Percent Reduction over control	Mean	Percent reduction over control
T_1	Removal of infested shoots	32.84 (34.94)	31.44	32.78 (34.92)	31.39	34.44 (35.92)	27.38
T_2	Light trap	19.21 (25.95)	59.89	18.97 (25.77)	60.29	19.82 (26.41)	58.21
T_3	Neem Seed Extract (5%)	20.48 (26.87)	57.24	19.36 (26.04)	59.48	21.38 (27.48)	54.92
T_4	Removal of infested shoots + Light trap	17.56 (24.64)	63.34	16.41 (23.89)	65.65	19.42 (26.08)	59.05
T_5	Removal of infested shoots + NSE (5%)	18.33 (25.33)	61.73	17.58 (24.79)	63.20	20.12 (26.59)	57.57
T_6	Light traps + NSE (5%)	16.89 (24.17)	64.73	15.23 (22.93)	68.12	18.17 (25.15)	61.69
T_7	Removal of infested shoots + Light Trap + NSE (5%)	11.83 (20.11)	75.30	11.39 (19.72)	76.16	13.06 (21.18)	72.46
T_8	Pesticides spray (Recommended)	10.25 (18.67)	78.60	11.09 (19.45)	76.78	12.87 (21.02)	72.86
T_9	Control (Untreated)	47.90 (43.79)		47.78 (43.72)		47.43 (43.52)	
	'F' test	Sig.		Sig.		Sig.	
	SE (M) ±	1.322		1.057		1.187	
	C.D. (0.05%)	3.963		3.167		3.557	

(Fig. in parenthesis are the arc sin transformations)

Table 3: Cumulative mean percent fruit infestation on weight and number basis

Treatment		Weight basis		Number basis	
		Mean	Percent Reduction Over control	Mean	Percent reduction over control
T_1	Removal of infested shoots	27.89 (31.87)	21.59	26.47 (30.95)	21.80
T_2	Light trap	17.22 (24.49)	51.58	16.56 (23.99)	51.07
T_3	Neem Seed Extract (5%)	18.78 (25.60)	47.20	17.87 (24.99)	47.20
T_4	Removal of infested shoots + Light traps	16.05 (23.61)	54.87	15.37 (23.06)	54.59
T_5	Removal of infested shoots + NSE (5%)	16.87 (24.19)	52.57	16.07 (23.62)	52.52
T_6	Light traps + NSE (5%)	15.78 (23.38)	55.63	14.68 (22.50)	56.63
T_7	Removal of infested shoots + Light Traps + NSE (5%)	11.48 (19.76)	67.72	11.03 (19.36)	67.41
T_8	Pesticides spray (Recommended)	10.72 (19.06)	66.14	10.15 (18.50)	70.01
T_9	Control (Untreated)	35.57 (36.61)		33.85 (35.57)	
	'F' test	Sig.		Sig.	
	SE (M) ±	1.122		0.937	
	C.D. (0.05%)	3.364		2.810	

(Fig. in parenthesis are the arc sin transformations)

The results of this study clearly indicates that T_7 (Removal of infested shoots + Light trap + NSE 5%) is proven to be the best alternative to insecticidal treatment. So T_7 can be suggested for the Non-Pesticidal Management of *Leucinodes orbonalis* in brinjal. Although insecticidal treatment proved to be the best, T_7 (Removal of infested shoots + Light trap + NSE 5%) proved to be the best for Non – Pesticidal management. The present findings are quiet consistent with the findings of (Yousafi *et al.* 2018) [5] who carried out a study in Pakistan at Sahiwal on spring sown brinjal crop during 2013 from May 15 to September 30 and found that cultural control (removal of infested shoots) combined with physical control (use of light traps) proved to be an adoptable and practical strategy for management of BFSB. Kolhe *et al.* (2017) [6] who reported 4.96 percent shoot infestation with 66.16 percent reduction over control with Cypermethrin 25 EC. Similar results were also reported by Raj and Tayade (2018) [7], who observed 11.67 percent shoot infestation with 54.32 percent reduction over control with Cypermethrin 25 EC. Budhvat and Magar (2014) [8] reported 18.21, 20.16, 33.77 percent shoot infestation with 62.26, 58.22, 30.02 percent reduction over control with the treatments removal of infested shoots + NSE (5%), Neem seed extract (5%), Removal of infested shoots. These findings were quiet consistent with the present findings where 10.25 percent shoot infestation with 78.60 percent reduction over control in T_8

(Insecticidal spray), 18.33 percent shoot infestation with 61.73 percent reduction over control in T_5 (Removal of infested shoots + NSE 5%), 20.48 percent shoot infestation with 57.24 percent reduction over control in T_3 (Neem seed extract 5%), 32.84 percent shoot infestation with 31.44 percent reduction over control in T_1 (Removal of infested shoots) was observed 3 days after spraying.

Dongarjal and Ashwani (2017) [9] reported shoot infestation up to 4.76 percent with 74.61 percent reduction over control after 7 days of insecticidal spray treatment (Cypermethrin 25 EC). Budhvat and Magar (2014) [8] reported shoot infestation of 16.74 percent with 65.16 percent reduction over control with treatment removal of infested shoots + NSE (5%), Infestation of Shoot up to 19.07 percent with 60.31 percent reduction over control with neem seed extract and 32.78 percent reduction in shoot infestation and 31.39 percent reduction over control with treatment removal of infested shoots. Similar observations were recorded in the present findings where in 11.09 percent shoot infestation with 76.68 percent reduction over control with treatment Insecticidal spray (recommended), 17.58 percent shoot infestation with 63.20 percent reduction over control with treatment T_5 (Removal of infested shoots + NSE 5%), 19.36 percent infestation of shoot with 59.48 percent reduction over control in treatment T_3 (Neem seed extract 5%) and 32.78 percent infestation to shoot with 31.39 percent reduction over control in T_1 (Removal of infested shoots) was observed 7 days after spraying.

Kolhe *et al*. (2017) [6] reported shoot infestation 10.33 percent with 53.73 percent reduction in incidence over control in insecticidal spray treatment after 14 days of spraying. Budhvat and Magar (2014) [8] reported shoot infestation of 19.77 percent with 58.67 percent reduction over control with the treatment Removal of infested shoots + NSE (5%). Similarly Pawar *et al*. (2009) [10] also reported 27.9 percent shoot infestation with 38.11 percent reduction over control. Budhvat and Magar (2014) [8] reported Neem seed extract (5%) had 21.15 percent shoot infestation with 55.79 percent reduction over control. Chowdhury *et al*. (2017) [11] reported shoot infestation 30.33 percent with 23.14 percent reduction over control with treatment removal of infested shoots. All these treatments are quiet consistent with the present findings in which treatment T_8 insecticidal spray (recommended) recorded 12.87 percent shoot infestation with 27.38 percent reduction over control, Removal of infested shoots + NSE 5% recorded 20.12 percent shoot infestation with 57.57 percent reduction over control, 21.38 percent shoot infestation and 54.92 percent reduction over control in treatment T_3 (Neem seed extract 5%) and in treatment T_1 (Removal of infested shoots) recorded 34.44 percent shoot infestation and 27.38 percent reduction over control 14 days after spraying.

In insecticidal treatment Dileep *et al*. (2008) [12] recorded 24.13 percent fruit infestation and 50.65 percent reduction in infestation over control. Chowdhury *et al*. (2017) [11] observed 26.47 percent infestation to fruits and17.51 percent reduction over control in treatment removal of infested shoots. These findings are quiet consistent with the present findings of insecticidal management in which 10.72 percent damage to fruits and 66.14 percent reduction in damage over control. In treatment Removal of infested fruits, damage to fruits was up to 27.89 percent and 21.59 percent reduction in damage over control was observed which are quiet consistent with the present findings and support the results and hence for non pesticidal management of brinjal shoot and fruit borer T_7 (Removal of infested shoots + Light Trap + NSE 5%) can be recommended as it is performing at par with pesticidal management.

4. Conclusion

Brinjal shoot and fruit borer is the major constraint in cultivation of brinjal. Indiscriminate and excessive use of insecticides over a long period of time leading to insecticide resistance along with resurgence and destruction of natural enemies disturbing balance of nature. For safer management and suppression of this pest T_7 (Removal of infested shoots + Light Trap + NSE 5%) can be recommended which may help in reducing the use of insecticides on brinjal fruits and also will help to reduce the residue problem on fruits and resistance problem in insects.

5. Acknowledgement

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